THE USE OF NURSE SPECIES IN THE AFFORESTATION OF UPLAND HEATHS

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SUMMARY

Some early observations on the effects of nurse crops on Sitka spruce in an experimental area on the upland heaths are recorded. They explain how it was found that the importance of the nurse crop was due to its capacity to reduce competition from heather, rather than to any sheltering effect. The spruce roots were found to spread under the nurse crop, especially if Japanese larch, where they root in the larch litter and surface soil by then free from heather. Some problems of tending the crop so as to give the spruce room to grow without removing all the nurse species and permitting the return of the heather are explained, and various patterns for mixing the species less intimately are described. The early indications of these new experiments are given.

The upland heaths are characterized by podzolized soils, comprising a thin peaty layer overlying a zone of compacted leached soil below which a pan is usually found. The dominant vegetation is heather (*Calluna vulgaris*), whilst *Erica* spp., *Trichophorum caespitosum* (*Scirpus*), *Carex* spp. and *Eriophorum* spp. are usually to be found in varying proportions. Traces of pine scrub (*Pinus sylvestris*) and birch scrub (*Betula* spp.) may occur, though their regeneration and growth have been restricted over the centuries by burning and grazing. Such heathland is usually parched in summer, waterlogged in winter, and is highly acid.

Before the beginning of State planting little was known about the afforestation of such ground, and in 1928 a series of experimental plantations was initiated in the Allerston series of forests which lie along the southern fringe of the North Yorkshire moors. Two of the areas involved have been described in detail elsewhere,[1] and it is on these areas that the experiments to be dealt with in this paper have been studied.

Early experiments on direct planting indicated that:

1. Pines, such as Scots pine (*Pinus sylvestris*), Corsican pine (*Pinus nigra* var. *calabrica*) and lodgepole pine (*Pinus contorta*), could be established, though their growth was slow.
2. European larch (*Larix decidua*) and Japanese larch (*Larix leptolepis*), failed to survive.
3. Sitka spruce (*Picea sitchensis*) went into immediate check.

Subsequent experimentation demonstrated that ploughing would speed up the early growth of pines and enable Japanese larch to become established, but would do little more than delay the onset of check in spruce. The application of slow-acting fertilizers such as basic slag or ground mineral phosphate usually effected a general improvement in early growth for most species, but did not prevent the onset of check in spruce. Hardwoods such as beech (*Fagus sylvatica*), sycamore (*Acer pseudoplatanus*), birch (*Betula* spp.),

alder (*Alnus* spp.) and sweet chestnut (*Castanea sativa*), did not show much promise.

One of the principal projects in the Allerston experimentation centred on ways and means of growing Sitka spruce, because pines and larch were likely to yield relatively low volumes of timber. Sitka spruce, on the other hand, was known to be a high yielder where it could be grown successfully.

The early experiments were essentially trials covering the problems of choice of species, methods of cultivation, and forest manuring. Included in the choice of species were several mixtures such as pine with spruce, pine with larch, the latter sometimes with a 20 per cent proportion of hardwoods. The method of mixing was one or two plants of pine alternating with single plants of larch or spruce in each row, hardwoods when present being inserted singly at wider intervals.

About the end of 1937 it became evident that in one of these mixtures, the Scots pine was assisting the growth of the spruce. This occurred in a 10-year-old planting on ground which had been ploughed 3 to 6 in. deep. The pan was relatively shallow, and had been ruptured by the plough at odd intervals. At this stage of events the Sitka spruce in pure plantation were in a state of partial to severe check, their colour being yellowish-green and their needles small. Where mixed with Scots pine, quite a number of the spruce showed much better needle development and improved colour. Measurements taken over the entire experiment gave the following data:

TABLE I

COMPARISON OF SITKA SPRUCE PURE AND IN MIXTURE WITH SCOTS PINE AT TEN YEARS OF AGE

	Planted Pure		Mixed Plantation			
	Sitka spruce		Sitka spruce		Scots pine	
	Mean height feet	Mean 1937 growth inches	Mean height feet	Mean 1937 growth inches	Mean height feet	Mean 1937 growth inches
Unmanured	1·8	1·4	2·4	4·1	4·3	11·3
Basic slag applied shortly after planting	2·6	3·4	3·2	6·6	5·2	12·9

It will be seen that whilst the average annual growth of both species had been slow, the growth of the spruce in 1937 had been at least doubled by the proximity of pine.

These facts were considered sufficient evidence to warrant more detailed observations and trials on the possibility of using pine as a nurse for spruce. Neither the data nor the plantings themselves offered any clue as to how the spruce could be benefited by the

proximity of pine, apart from shelter. The first practical step taken was the introduction of Sitka spruce into 5- to 7-year-old Scots pine and Corsican pine on land which had been ploughed 8 in. to 10 in. deep, i.e., deep enough to ensure that the pan was frequently broken. In each of these introductions the spruce checked and was outgrown by the pines for reasons which will be explained later.

In addition to the trials of tree species as nurses, use was also made of the legumes, broom (*Sarothamnus scoparius*) and perennial lupin (*Lupinus polyphyllus*). Broom proved itself in repeated trials as a short term nurse (see Table III), but was either suppressed by the tree species or died out when 12 to 15 years of age. The lupins began to die out after five years, and being mixed with broom, their effect could not be ascertained. No further attempts were made with lupins because broom proved to be much longer lasting. Broom, unfortunately, carried with it certain disadvantages, such as the cost of seed collection, establishment and cutting back to free the nursed species. Attention thus remained concentrated on the possibilities of using tree species as nurses to avoid, first of all, the heavy additional establishment charge associated with broom, and secondly, to make use of a nurse which would function longer and possibly form part of the main crop, should this, at a later stage, appear desirable.

Two years after the data in Table I were compiled a need for tending began to make itself apparent in the mixed plantation. Reference to Table I shows that not only were the pines taller than the spruce, but their rates of growth in 1937 were two to three times that of the spruce. Table II illustrates the importance of this point still further.

TABLE II

COMPARISON OF SITKA SPRUCE PURE AND IN MIXTURE WITH SCOTS PINE AT 12 YEARS OF AGE

	Planted Pure		Mixed Plantation			
	Sitka spruce		Sitka spruce		Scots pine	
	Mean height feet	Mean 1939 growth inches	Mean height feet	Mean 1939 growth inches	Mean height feet	Mean 1939 growth inches
Unmanured	2·0	1·7	3·2	6·4	6·1	11·2
Basic slag applied shortly after planting	3·1	2·8	4·2	7·0	7·3	12·2

These differences between species for growth rates and height explain the need for tending, for the overtopped spruce began to suffer physical damage from pine branches and from lack of light, and resort was made to removal of the branches or even the complete

removal of occasional pine trees. This amounted to a partial removal of the nurse which a year or so previously had appeared to be so necessary. The only feasible solution to the dilemma was that the method of mixing should be redesigned to give the spruce more light in the early stages of the crop. This led to the use of the alternate double row method of mixing, i.e., two rows of pine alternating with two rows of spruce, and to the single row of pine alternating with double rows of spruce which are illustrated in diagram 1. The double row method of mixing offered easier scope for preserving the pine for a greater length of time, and was, therefore, to be preferred.

The alternate double row mixture was essentially a means of giving more light for a longer period of time to the spruce without resource to expenditure on branch pruning and unprofitable stem removal of pine, such as had occurred with the more intimate mixture of two pines to one spruce.

At this stage of events the fundamental principles causing the beneficial effects of one tree species on another were by no means understood, though the need for overhead freedom to the spruce had become apparent. By the end of 1942 the preliminary but nevertheless dramatic effects on tree growth of the suppression of *Calluna* by mulching had been demonstrated, a more detailed account of which has been published elsewhere.[2] This apparent correlation between check in spruce and the presence of *Calluna* was a factor which had not been taken into account when spruce was introduced into 5- to 7-year-old Scots and Corsican pine, and it readily explained why the spruce had checked and had rapidly been overtopped by the pine. It should be noted that after ploughing, irrespective of pre-burning, *Calluna* had begun to re-establish itself with great vigour within 3 to 4 years.

During the course of observations spread over a number of years, it was repeatedly noted that wherever Sitka spruce adjoined Japanese larch with the latter in canopy a proportion of the spruce roots travelled considerable distances within the *Calluna*-free area occupied by the larch, and that such roots branched freely. Spruce roots which travelled within the area occupied by the spruce, where *Calluna* was rampant, were shorter, thinner and had much smaller tips. It was also observed that of the spruce adjoining the larch, those making relatively good growth had some of their roots below the larch, while those remaining in check had their roots confined to the *Calluna*-covered area. It was further observed that the spruce roots under larch travelled below the layer of larch needle litter, and only occasionally did side branches descend into the ploughed soil. Since Japanese larch was known by observation to suppress *Calluna* more quickly than any other conifer in common use, as well as to provide a litter in which spruce roots would travel, it appeared to have a potential use as a nurse to spruce. Thus, by using Japanese larch as a nurse, it was hoped to simulate the effects of mulching without financial expenditure over and above the normal cost of establishment.

Observations also indicated that single rows of larch would be

less effective for heather suppression than two or more rows. Double rows of larch were regarded as the minimum for effective *Calluna* suppression. Moreover, double rows of larch would give considerable latitude for conversion to pure spruce or to maintain a mixture, whichever appeared desirable at a later stage.

Excavations demonstrated that the roots of at least two rows of Sitka spruce adjacent to Japanese larch would find their way below the larch.

The use of three rows of spruce would ensure adequate light for a lengthy period should the spruce lag behind the larch, pending the development of the larch mulch. This would avoid any need for the removal of larch branches.

The thinning of intimate mixtures, i.e., alternate plant or alternate row mixtures, calls for greater skill than does the thinning of strip or multiple row mixtures. It is very seldom that two species grow at the same rate. One is usually overhauling or outgrowing the other. Intimate mixtures seldom give a good proportion of the overhauling species and the presence of a slower-growing species can lead to a need for liberation in the thicket stage, early thinning, and often to a choice between a vigorous specimen of one species and a less vigorous specimen of a more desirable species. In a multiple row mixture the competition between species for light is considerably reduced, and is replaced by a competition within each species. This enables ordinary thinning to be practised without the need to select between species. Even on the edge rows of a multiple row mixture, each tree has others of the same kind on three sides, though choice between species along edges will have to be made from time to time. The distinction between competition within a species in multiple row mixing and competition between species in intimate mixtures is important. The formation of canopy is an important form of tree competition, and there is some variability between species in their methods of forming canopy. Spruce branches meet at a low level, whereas pine branches usually do so about 4 or 5 ft. above ground level. This variable level of canopy formation is an added difficulty in intimate mixtures of pine and spruce.

As a result of these considerations, a new experiment was planted in 1943 in which two rows of Japanese larch alternated with three rows of Sitka spruce. The 1943 trial plantation has so far shown a very interesting series of developments. When the *Calluna* reinvaded three to four years after planting, the spruce deteriorated in colour and vigour. A couple of years or so later the double rows of Japanese larch began to suppress the *Calluna*, and an improvement in colour and growth of the adjacent spruce became evident. Excavations later revealed that spruce roots had reached the *Calluna*-free ground below the larch, and that immediately below the layer of larch needle litter and on the surface of the mineral soil layer there were many spruce root tips of a healthy and vigorous appearance. Rooting by the spruce within its own area, where the *Calluna* remained vigorous, was meagre. At about the tenth year the spruce began to form canopy, and to suppress the *Calluna* below itself. Checking, associated with *Calluna*, had in fact been

overcome without recourse to any applied treatment beyond those of normal cultivation, planting and manuring. Tending in the form of removal of nurse branches had never been necessary.

Comparative heights of this and of other plantings are given in Table III. Of the other plantings in Table III, reference must be made to the most intimate of all, the alternate single rows of pine and spruce. Here it will be seen that this mixture, as far as can be ascertained in the absence of further replications for comparison, appears to be more successful than either the alternate double row mixture, or the double rows of spruce with single rows of pine. This is quite in keeping with previous observations that Scots pine does have a nursing effect on spruce apart from its ability to suppress *Calluna*. Here we are dealing with intensive cultivation which will be helping the spruce, but observation indicates that whilst none of the spruce in the 3 S.S./2 J.L. mixture is being physically suppressed by the nurse, some of the spruce in the alternate row pine/spruce units are beginning to be suppressed.

TABLE III

HEIGHTS IN FEET OF VARIOUS SPECIES IN MIXTURE AT THIRTEEN YEARS OF AGE

Crop	Complete Ploughing 12 in.–16 in. deep		Single Furrow Ploughing 12 in.–16 in. deep	
	Sitka spruce	Nurse species	Sitka spruce	Nurse species
3 SS/2 JL	13·2	14·3	12·4	11·5
SS/Broom	13·3	Dying out	9·0	Dying out
2 SS/2 SP	9·4	12·2	8·5	12·9
2 SS/1 SP	7·5	12·0	8·5	12·4
1 SS/1 SP	10·5	13·0	10·6	13·5
SS pure	6·0	—	6·0	—

3 SS/2 JL = 3 rows Sitka spruce alternating 2 rows Japanese larch
2 SS/2 SP = 2 rows Sitka spruce alternating 2 rows Scots pine, etc.
All the above received basic slag at planting.

Data taken from unreplicated units (Broxa Experiments 8 and 9, P. 43).

In 1951 a further series of multiple row mixtures was laid down. These incorporated the following developments:

1. Japanese larch remained as the principal nurse, but was planted in three-row strips. The extra row was added to minimize exposure effects observed in the 1943 plantings and to ensure that the larch would not be completely suppressed should the spruce become really vigorous.

2. Because of the surface rooting habit of the spruce in the larch litter, which might well be a disadvantage in a drought, and of the observed, but not understood, nursing effect of Scots pine, it was

decided to try an additional mixture in which Scots pine was incorporated. The latter consisted of three rows Japanese larch, three rows nursed, three rows Scots pine, three rows nursed, three rows Japanese larch, etc.

3. Following the success of the 1943 plantings, it was felt that the range of main crop species might well be extended. In addition to Sitka spruce, western hemlock (*Tsuga heterophylla*), Douglas fir (*Pseudotsuga taxifolia*) (*Douglasii*) and grand fir (*Abies grandis*) were included each with larch and with larch and pine nurses.

The 1951 plantings are as yet too young to show nursing effects ; they are mentioned solely to illustrate current lines of thought. It may be added that three-row nursing using Japanese larch with or without Scots pine is not necessarily regarded as the final answer to the question of how to make the best use of nurse species. There are some who would prefer groups rather than three-row strips, whilst further experience might well point towards five or even more rows of the nursed species.

REFERENCES

[1]Scarborough Field Naturalist Society (1953). The Natural History of the Scarborough District, pp. 286–96.

[2]J. Weatherell (1953). The Checking of Forest Trees by Heather. *Forestry*, **36** (1) pp. 37–40.